Governing Climate Engineering:
A Proposal for Immediate Governance of Solar Radiation Management

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Solar Radiation Management (SRM) is an umbrella term for a set of proposed technological responses to climate change. SRM technologies would reflect a small amount of incoming solar radiation back into space before it can warm the planet. Leading proposals include introducing reflective particles into the stratosphere (stratospheric aerosol injection or "SAI") and artificially whitening clouds (marine cloud brightening or "MCB"). Other potential ways to increase planetary albedo range from brightening natural or human-made features at ground level all the way up to introducing mirrors into Earth's orbit.

SRM has been described as "fast, cheap, and imperfect" (Mahajan et al 2018). Some computer-based modeling and studies of natural analogues (most notably volcanic eruptions) have suggested that planetary-scale SAI, in particular, could generate rapid and, depending on the magnitude of an intervention, dramatic cooling (NRC 2015). This suggests that SRM could be a "fast" response to climate change compared to mitigation. SRM could also be relatively inexpensive. One study estimated the cost of a global SAI scheme at around $2.5 billion per year for the first 15 years (Smith and Wagner 2018), although other studies have estimated costs in the range of $10-20 billion per year (Moriyama et al. 2017).[1] This is "cheap" when compared to the costs associated with mitigation, or when compared to the projected costs, including welfare costs, of unchecked atmospheric warming. Finally, SRM is "imperfect." If deployed, it would not return the planet to some predictable former state. Nor is it a substitute for aggressive greenhouse gas reductions. There are also risks attached to SRM, some that cut across the entire enterprise and some that are dependent on type and scale of use, as discussed below.

Thus, although SRM may emerge as a useful component of a global response to climate change, there is also good reason for caution. There are questions about whether SRM should be developed at all, or whether prompting too open a consideration of SRM distracts from mitigation and adaptation. If research moves forward, how ought it to be governed? What can be done to steer SRM developments towards the climate risks that face the most vulnerable? How can SRM be effectively and fairly governed?

In fall 2018, the Academic Working Group on Climate Engineering Governance (the Working Group) released a policy report, "Governing Solar Radiation Management," which addressed these questions and made recommendations for near-term SRM governance.[2] The Working Group consisted of fourteen scholars with a variety of interests and disciplinary expertise in global environmental governance. The Working Group met for five deliberative workshops

[1] Cost estimates for SAI vary depending on assumptions of deployment technique and for given degrees of cooling. Importantly, Smith and Wagner (2018) provide an estimate for low altitude injection, whereas Moriyama et al. (2017) provide an estimate for high-altitude injection using newly designed aircraft (which lowers the cost substantially from using existing aircraft).

[2] The Working Group was assembled by the Forum for Climate Engineering Assessment (FCEA) based at American University in Washington D.C., with support for meetings and other activities provided by the V. Kann Rasmussen Foundation, the Rockefeller Brothers Fund, and Open Philanthropy.

between March 2016 and February 2018. The chief findings of the Working Group's report are detailed below.[3]

Background on the Process

The Working Group faced significant challenges. The group was tasked with distilling consensus governance recommendations in an area outside their immediate empirical expertise. That is, although Working Group members were all established experts in various aspects of global environmental governance, they were selected precisely because they were new to the empirical area of climate engineering. The Forum for Climate Engineering Assessment (FCEA), which assembled the Working Group, made this decision to address concerns that discussions surrounding climate engineering were too insular (see, for example, Hamilton 2013). The members of the group had to quickly become experts in the existing SRM governance literature and policy conversation, so that they could bring their established expertise to the topic.[4]

Throughout the process, the group was divided–sometimes sharply—on the ultimate wisdom of deploying SRM technologies. This reflected the choice to convene a group with diverse perspectives, leading to a very different report and set of recommendations than would have been produced had the group consisted solely of ardent supporters or vehement critics of SRM technologies.

Due to its divided nature, the group decided to leave unanswered the basic question of whether SRM technologies are desirable. Instead, it started from a shared acknowledgement that SRM research is moving forward, if slowly, and that the largely ungoverned status quo is unsatisfactory. The group bounded its deliberations by focusing on governance of plausible near-term (meaning out to 2025) SRM research pathways rather than on speculative far-term deployment scenarios. As a result, its recommendations focused on what might realistically be done to govern SRM technologies within the current international system.

Governance objectives

Governing the development (or not) of SRM means navigating between sometimes competing potential benefits and risks. When it comes to near-term SRM research, the Working Group recognized that there are risks associated with allowing research, but that there are also risks associated with *not* allowing research. The Working Group also identified a range of risks associated with deploying or not deploying SRM and with governing SRM.

[TEXT BOX: Risk-Risk Tradeoffs in SRM Research and Deployment]

[3] All recommendations presented in this article are derived from the Working Group Report (See Chhetri et al. 2018).

[4] The Working Group members quickly developed such expertise as is evidenced in a series of peer reviewed publications on SRM governance published by group members since the group was assembled in March 2016. See, for example Conca 2018, Flegal and Gupta 2018; Gupta and Möller 2018; Jinnah 2018; Jinnah and Bushey 2017; Jinnah and Nicholson 2019; Jinnah et al. 2019; McKinnon 2018; Nicholson et al. 2018; Thiele 2018.

Decisions about how or whether to research, deploy, and govern SRM face a series of risk-risk tradeoffs. The Working Group's report summarizes the literature on these risks (Chhetri et al. 2018, pp. 4–5).

Some commentators worry that researching SRM creates risks of: a "moral hazard" effect, in which SRM research distracts from mitigation efforts; technological "lock-in" that prematurely focuses research on particular SRM technologies or inappropriately accelerates a drive toward deployment; capture by special interests; and the facilitation of rogue deployment. Others worry that *not* researching SRM would leave societies without adequate information about SRM and without the ability to deploy SRM quickly or responsibly if that were deemed appropriate.

Commentators have flagged a wide range of potential risks from deployment. These include undesirable environmental impacts and the inequitable distribution of burdens and benefits, as well as risks of geopolitical conflict and technological lock-in. In some circumstances, deployment could create a risk of "termination shock," in which an abrupt cessation of SRM leads to rapid warming. These risks would need to be weighed against the grave environmental, social, ethical, and geopolitical risks arising from climate change.

Different governance arrangements could create additional risks. Poorly designed or implemented governance mechanisms could channel SRM research in inappropriate directions or make it harder to integrate discussions of SRM into the broader climate policy debate. Since governance could either facilitate or restrain research, governance mechanisms must navigate between inappropriately shackling research and exacerbating the risks of research. Finally, some ways of designing governance could impose undue costs on or exclude those most vulnerable to climate change and the impacts of SRM.
[END TEXT BOX]

The efforts of the Working Group were, from inception, meant to be pragmatic and policy-focused. The ultimate goal was to "bridge the gap between the existing academic literature on the governance of SRM and the need for actionable, authoritative advice for governing SRM in the near term, in particular" (Chhetri et al. 2018, p. 10). With this goal in mind, the deliberations of the Working Group settled on a set of governance objectives to guide their jointly-authored report. That is, the group asked and answered the questions, "What near term steps should be taken toward the governance of [SRM]? What objectives should those actions serve?" (Chhetri et al. 2018, p. 1).

The Working Group identified four objectives for SRM governance:

Objective I — Keep mitigation and adaptation first.
Centrally, governance must ensure that if SRM is ever considered, it remains subsidiary to mitigation and adaptation measures. SRM does not replace the need for large-scale emission reductions for a host of reasons, including but not limited to the fact that SRM does not address many climate impacts, such as ocean acidification, and if SRM is ever deployed, multiple aspects of the climate may be affected, such as precipitation and regional temperature patterns, thereby introducing more uncertainty into an already changing climate.

Objective II — Thoroughly and transparently evaluate risks, burdens, and benefits

Developing the capacity for broad-based assessment of potential risks, burdens, and benefits of SRM will be necessary to ensure that society can anticipate, understand, reduce, and manage associated risks, which will vary depending on the circumstances of deployment. Importantly, "broad-based" assessment entails an inclusive and transparent approach that allows for meaningful input from diverse voices, including those who are most vulnerable to climate change or any potential risks from SRM research or deployment. Conducting this assessment will require both social capacities, such as institutions for settling disputes and making decisions as conditions change, as well as technological capacities, such as satellites for monitoring any potential field tests or deployment.

Objective III — Enable responsible knowledge creation
Governance should ensure that any SRM-related research is responsive to societal needs and concerns to the greatest extent possible. This serves two purposes. First, governance arrangements can facilitate research that is transparent, accountable, and socially appropriate, as well ensure that this research can anticipate and is responsive to societal needs and concerns. Second, these arrangements can help to prevent undesirable or irresponsible research pathways and outcomes. In order to pursue this objective, it will be necessary, but not sufficient, to disseminate information about research and its findings in publicly accessible ways; develop ways for diverse groups, including marginalized communities to contribute to and shape research programs; and clarify the responsibilities of researchers engaged in SRM research while still enabling responsible knowledge creation.

Objective IV — Ensure robust governance before any consideration of deployment
Governance should begin the near-term work of establishing effective institutions and norms to govern decisions about potential deployment. This near-term work will focus on governance of research as well as how SRM is deliberated, laying the groundwork for how decisions about potential deployment will be governed down the road. Pursuing this objective requires expanding the capacity of existing institutitions and perhaps creating new ones. This will require coordination between numerous countries and actors with diverse interests. Therefore, the arrangements for governing near-term SRM research must be flexible enough to evolve alongside SRM research and changing societal needs, and there must be a good fit between institutions' mandates and capacity and the demands of evolving SRM governance.

Recommendations: Concrete Near-term Governance Steps

To advance the governance objectives identified above, the Working Group developed twelve recommendations, grouped into three clusters. The recommendations focused on the near term, for two primary reasons. First, SRM technologies are largely conceptual. While there has been computer modelling and examination of natural analogues (e.g. volcanic eruptions), there has so far been only modest interest in outdoor experimentation relating to any SRM scheme that might ultimately have large climatic impacts. Any governance moves at this point would largely be anticipatory, looking to get out in front of an emerging technology that might one day become real. The context in which SRM is evolving is always in flux, making the issuing of firm longer-term recommendations about governance arrangements somewhat premature. Second, if research were to accelerate, there would be benefit in having some clear near-term signposts and rules of the road.

The twelve recommendations organized into their three clusters are as follows:

Create politically legitimate deliberative bodies
1. Establish a World Commission on SRM
2. Establish a Global Forum for stakeholder dialogue

Leverage existing institutions
3. Strengthen cooperation between international organizations
4. Assess and improve capacities for regional coordination and conflict resolution
5. Continue ongoing assessment role for IPCC and related processes
6. Develop foresight capabilities

Make research transparent and accountable
7. Report on SRM research and development activities in the global stocktake under the Paris Agreement
8. Institutionalize codes of conduct for responsible SRM research
9. Ensure that ongoing research includes international and interdisciplinary collaboration
10. Clarify funding streams
11. Develop a publicly accessible clearinghouse
12. Develop best practices for risk and impact assessments

Although a discussion of all twelve recommendations is beyond the scope of this paper, this section discusses the rationale behind each cluster and elaborates on 1-2 recommendations from each cluster.

The first cluster, creating politically legitimate deliberative bodies, is an essential aspect of developing legitimate processes and arrangements in the near term that enable the high-level international coordination and guidance that SRM demands while providing institutional mechanisms for facilitating meaningful stakeholder engagement. To date, most policy recommendations in this space, including the report summarized here, have come from scientists and other academic experts. The Working Group recommends creating institutions to enable more broad-based, participatory discussions of SRM as a potential response to climate change.

To this end, the Working Group recommends that the United Nations General Assembly should appoint a World Commission on SRM with members appointed by UN Secretary General based on various diversity criteria. This Commission should have the mandate to debate "first-order questions about whether and to what end SRM should be researched and developed, and how it fits within a broader climate response landscape" (Chhetri et al. 2018, p. 30). In the near term, important questions to be discussed by the Commission include whether to impose a moratorium on certain forms of SRM research or deployment, and how to develop an intellectual property regime that ensures technological innovation is conducted in the public interest. Such a high-level representative Commission will enhance the political legitimacy of SRM research and garner the resources and attention needed to undertake various forms of broad-based engagement. Building on suggestions by Edward Parson (2017), the Working Group identifies design elements for the Commission, such as high-level authorization and sufficient staff and

resources. The Group refrains from endorsing any specific design because this will be developed through international negotiations.

Central to the World Commission's mandate would be to develop a Global Forum for Stakeholder Dialogue to engage a wide variety of stakeholders in "cross-border and cross-scale discussions on SRM and its governance" (Chhetri et al. 2018, p. 32). The Forum should identify relevant stakeholders, especially those which might be otherwise marginalized from global governance, such as: local communities, peasant organizations, indigenous peoples, youth organizations, women's groups, labor unions, and others. The Forum's mandate should include, inter alia, engaging stakeholders in SRM research; facilitating debate over SRM governance; and collecting policy preferences from stakeholders and their communities. To this end, the Forum should be connected to national and sub-national bodies. Importantly, the Working Group argues that the purpose of such a Forum should not be to arrive at consensus, but to initiate a "learning-oriented dialogue." Moreover, to make stakeholder engagement *meaningful*, contentious concerns must not be merely dismissed, but instead *all* concerns must be addressed and responded to. Finally, although it should be constituted by the World Commission, the Forum should be independent and empowered to set the agenda of and advise the Commission.

The second cluster of recommendations, to leverage existing institutions, is necessary to fulfill the short-term governance objectives developed by the Working Group. Given their reticence to discuss SRM, it is unlikely that states will create a new institution to govern SRM. Although a new institution for SRM governance may be desirable in the longer-term, existing institutions have the capacity and interest to govern various near-term elements of SRM (Nicholson et al 2018). These institutions can begin building the foundation for future governance and can achieve short-term governance goals, such as increasing transparency around SRM research.

To this end, cooperation between international organizations must be strengthened, a task that should be pursued jointly by secretariats of relevant international organizations, national heads of government research offices, and the UN Chief Executives Board for Coordination. Increasing coordination between international organizations working in the fields of sustainable development, agriculture, education, human health, and more helps to ensure that governance: is inclusive of institutional stakeholders, avoids duplication of effort, utilizes resources and expertise efficiently, and helps to identify existing governance capacities and gaps.

The Working Group also recommends an ongoing role for the Intergovernmental Panel on Climate Change and other relevant bodies in assessing the state of SRM research. Assessing SRM research within the established processes helps ensure that SRM is not discussed in a vacuum, but rather it is contextualized within current knowledge on climate change and mitigation and adaptation efforts. Furthermore, these assessments should incorporate literature that is critical of SRM and be multidisciplinary, including governance-related research and inquiries in ethics and justice.

The third cluster of recommendations, making research transparent and accountable, is necessary to ensure that SRM research is legitimate and that it is conducted in the public interest, with public participation and steering of research as appropriate.

To this end, the Working Group recommends that states be encouraged to report on SRM research and development activities under the Global Stocktake, the primary transparency-enhancing mechanism of the Paris Agreement. The Stocktake is intended to assess collective progress towards the goals of the Agreement and to inform the pledging of Nationally Determined Contributions (NDCs). Though the Stocktake is still being designed, if it receives a broad mandate to assess technologies that may impact the goals of the Agreement, the Working Group recommends that the Stocktake include a comprehensive account of SRM research efforts.

Finally, the Working Group recommends the development of a publicly accessible clearinghouse of all publicly funded and, to the greatest extent possible, privately funded SRM research. Such a clearinghouse would support public engagement in SRM research and help coordinate research priorities. The Working Group notes that although some actors may refuse to voluntarily contribute information, states should require these actors to participate with reasonable restrictions on the information that needs to be disclosed. The Working Group recommends a curated clearinghouse model that allows data to be contextualized to assist public understanding and use of the data, as opposed to a research database of individual studies (Craik and Moore 2014).

Conclusion

The Working Group argues that SRM governance should begin now. Some members see SRM development as desirable; some as potentially dangerous. Whatever the perspective, governance will be required to prompt the careful deliberation and oversight needed to make decisions about SRM in the societal interest. The Working Group's recommendations establish essential rules and institutional arrangements for near-term understanding and guidance of SRM research and begin building the scaffolding for effective long-term governance.

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